EVALUATION OF FALL CHINOOK AND CHUM SALMON SPAWNING BELOW BONNEVILLE, THE DALLES, JOHN DAY AND MCNARY DAMS

Annual Report 1999-2000

DOE/BP-15007-2

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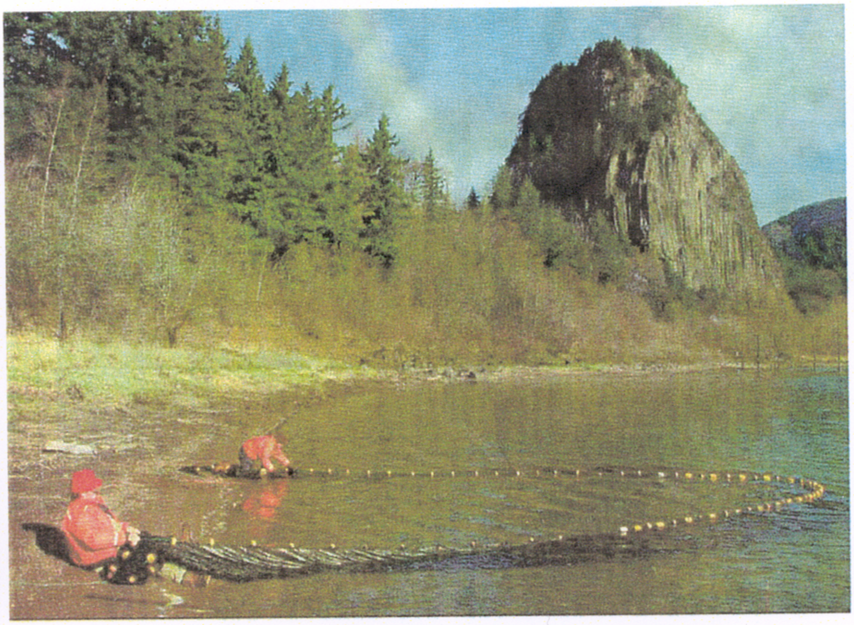

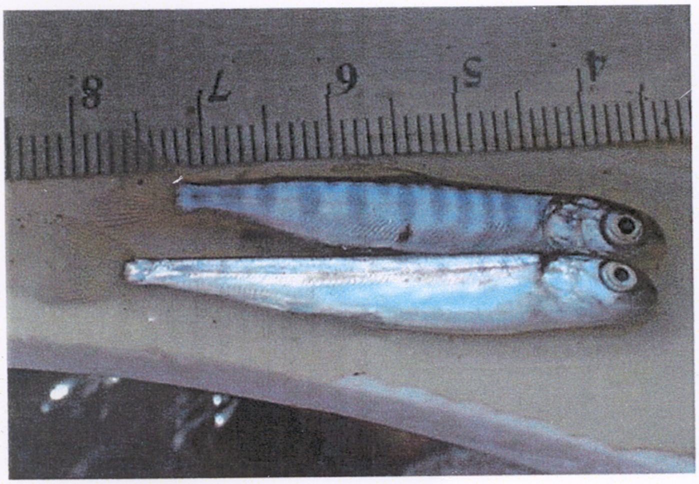

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OREGON DEPARTMENT OF FISH AND WILDLIFE
WASHINGTON DEPARTMENT OF FISH AND WILDLIFE

ANNUAL PROGRESS REPORT

REPORT TITLE:	1999-2000 Evaluation of Fall Chinook and Chum Salmon Spawning Below Bonneville, The Dalles, John Day and McNary Dams
PROJECT TITLE:	Evaluate Spawning Fall Chinook and Chum Salmon Below The Four Lowermost Columbia River Dams
PROJECT NUMBER:	99-003-01/99-003-02
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INTRODUCTION

This report describes work conducted by the Oregon Department of Fish and Wildlife (ODFW) and the Washington Department of Fish and Wildlife (WDFW) from 1 October 1999 to 30 September 2000. The work is part of studies to evaluate spawning of fall chinook salmon (Oncorhynchus tshawytscha) and chum salmon (O. keta) below the four lowermost Columbia River dams under the Bonneville Power Administration's Project 99-003. The purpose of this project is twofold:

1) Document the existence of fall chinook and chum populations spawning below Bonneville Dam (river mile (RM) 145), The Dalles Dam (RM 192), John Day Dam (RM 216), and McNary Dam (RM 292) (Figure 1) and estimate the size of these populations.

2) Profile stocks for important population characteristics; including spawning time, genetic make-up, emergence timing, migration size and timing, and juvenile to adult survival rates.

Specific tasks conducted by ODFW and WDFW during this period were:

1) Documentation of fall chinook and chum spawning below Bonneville, The Dalles, John Day and McNary dams using on-water observations;

2) Collection of biological data to profile stocks in areas described in Task 1;

3) Determination of spawning population estimates and age composition, average size at return, and sex ratios in order to profile stocks in areas described in Task 1;

4) Collection of data to determine stock origin of adult salmon found in areas described in Task 1;

5) Determination of possible stock origins of adult salmon found in areas described in Task 1 using tag rates based on coded-wire tag recoveries and genetic baseline analysis;

6) Determination of emergence timing and hatching rate of juvenile fall chinook and chum below Bonneville Dam;

7) Determination of migration time and size for juvenile fall chinook and chum rearing in the area described in Task 6;

8) Investigation of feasibility of determining stock composition of juvenile fall chinook and chum rearing in the area described in Task 6;

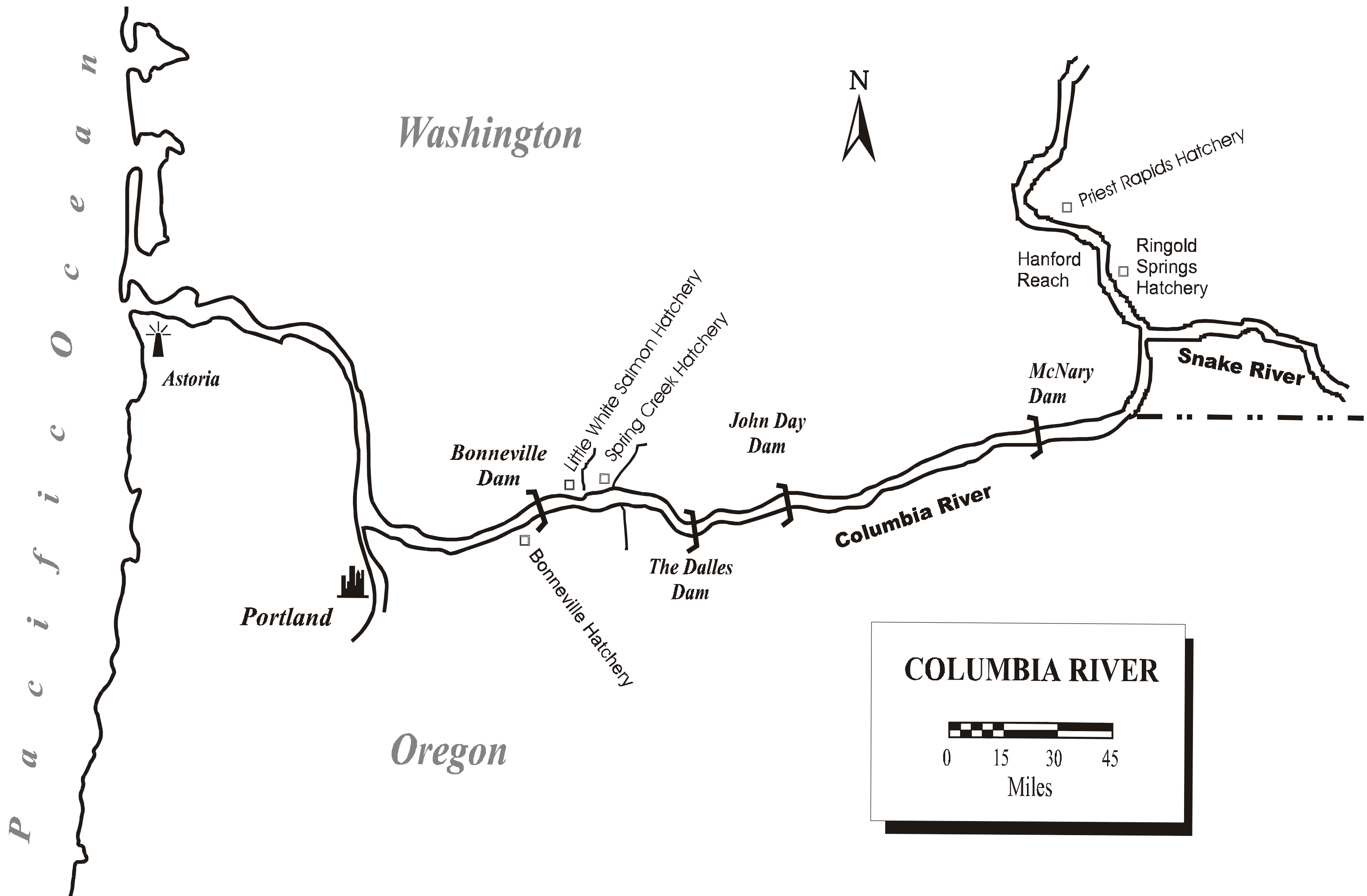

Figure 1. Location of dams, hatcheries, and production areas pertinent to the evaluation.

9) Documentation of entrapment in low-lying areas of juvenile fall chinook and chum rearing in the area described in Task 6;

10) Investigation of feasibility of coded-wire tagging juvenile fall chinook captured in the area described in Task 6 to determine juvenile to adult survival rate.

METHODS AND MATERIALS

Adult study

Spawning ground surveys of fall chinook and chum salmon below Bonneville, The Dalles, John Day, and McNary dams occurred from 5 October through 21 December 1999. The below Bonneville Dam study area is approximately two miles downstream from the dam, between river miles 141.0-143.5. The area includes Pierce and Ives Islands as well as the main channel of the Columbia River. Primary spawning areas are within the island complex and along the shorelines of the islands adjacent to the main channel of the Columbia River. The study area below The Dalles Dam includes waters along both shorelines for two miles downstream of the dam. Approximately seven miles of both shorelines below the John Day and McNary dams were surveyed, including potential spawning habitat surrounding islands just below the John Day Dam. A weekly count of spawning redds and numbers of live and dead fish were made from the bow of a jet boat and by wading in shallow water. In addition, locations of newly formed spawning redds were recorded using global positioning system (GPS) receivers.

Fish carcasses were examined and biological data was collected to profile stock for age composition, average size at return, and sex ratios. Scales from sampled fish were removed and analyzed to determine total age. To assist in determining stock origin of salmon found in the study areas, carcasses were inspected for fin clips. The snouts of fish with adipose fin clips were removed and kept for future coded-wire tag recovery and analysis.

To assist in determining whether fish had successfully spawned, female carcasses were examined for the presence of eggs. Except for the Bonneville fall chinook group, tissue samples were collected from all populations for genetic stock identification (GSI). GSI work was not performed on the Bonneville fall chinook population since genetic baseline data for this group was completed in 1998.

A capture-recapture carcass tagging study known as the Worlund technique was used to assist in providing spawner population estimates (Appendix A). The mathematical model used to analyze data was developed by G. Paulik (prepared by D. Worlund) of the University of Washington and is a use of the multiple release and recapture methods of G. Seber and G. Jolly (Biometrika Vol. 49, 1962).

Each week newly found fall chinook and chum carcasses were marked with a unique colored plastic tag and returned to their original location. The number of new tags issued and the number of tags recovered from previous week's tagging were recorded. Carcasses found with a tag were mutilated to identify them as recoveries. A population estimate was generated after tag data was analyzed by the above method.

Juvenile study

The juvenile portion of the study concentrated on areas where spawning occurred below Bonneville Dam in 1999. Investigations of emergence timing and hatching rates of fall chinook and chum salmon fry originally were to be conducted using emergent traps. Traps were to be placed over redds identified by GPS waypoints. After examining Bonneville Dam flow data and visiting prospective sampling areas in late winter, it was determined emergent trapping would not be possible. Depths over redds in the Ives and Pierce Islands area were seven to 15 feet and flows were in excess of 250 thousand cubic feet per second (kcfs). At such velocities it would be difficult to employ emergent traps and unsafe to maintain them.

To determine emergence timing an alternative method to trapping was developed. Estimated hatching and emergence dates were calculated in temperature units (TU) which are measured in Celsius degree-days. The dates were calculated in TU from the initiation of spawning to hatching of eggs (500 ^{o} C. TU for chinook and 600 ^{o} C. TU for chum) and beginning and ending of emergence (1,000 ^{o} C. TU for chinook and 800 ^{o} C. TU for chum). Water temperatures used in TU calculations were taken from Bonneville Dam readings and from temperature gauges maintained by U. S. Fish and Wildlife Service and located in the Ives Island area.

Sampling to determine the time and size juveniles migrated from the areas used for rearing began 26 January 2000. Surveys were conducted twice weekly through 11 July 2000. Sampling was conducted in seven designated locations below Bonneville Dam (Figure 2). The locations were selected by reason of their proximity to redds identified during spawning ground surveys in 1999, representative habitat and seining accessibility. Specific sampling areas within the seven locations changed with variations in river flows.

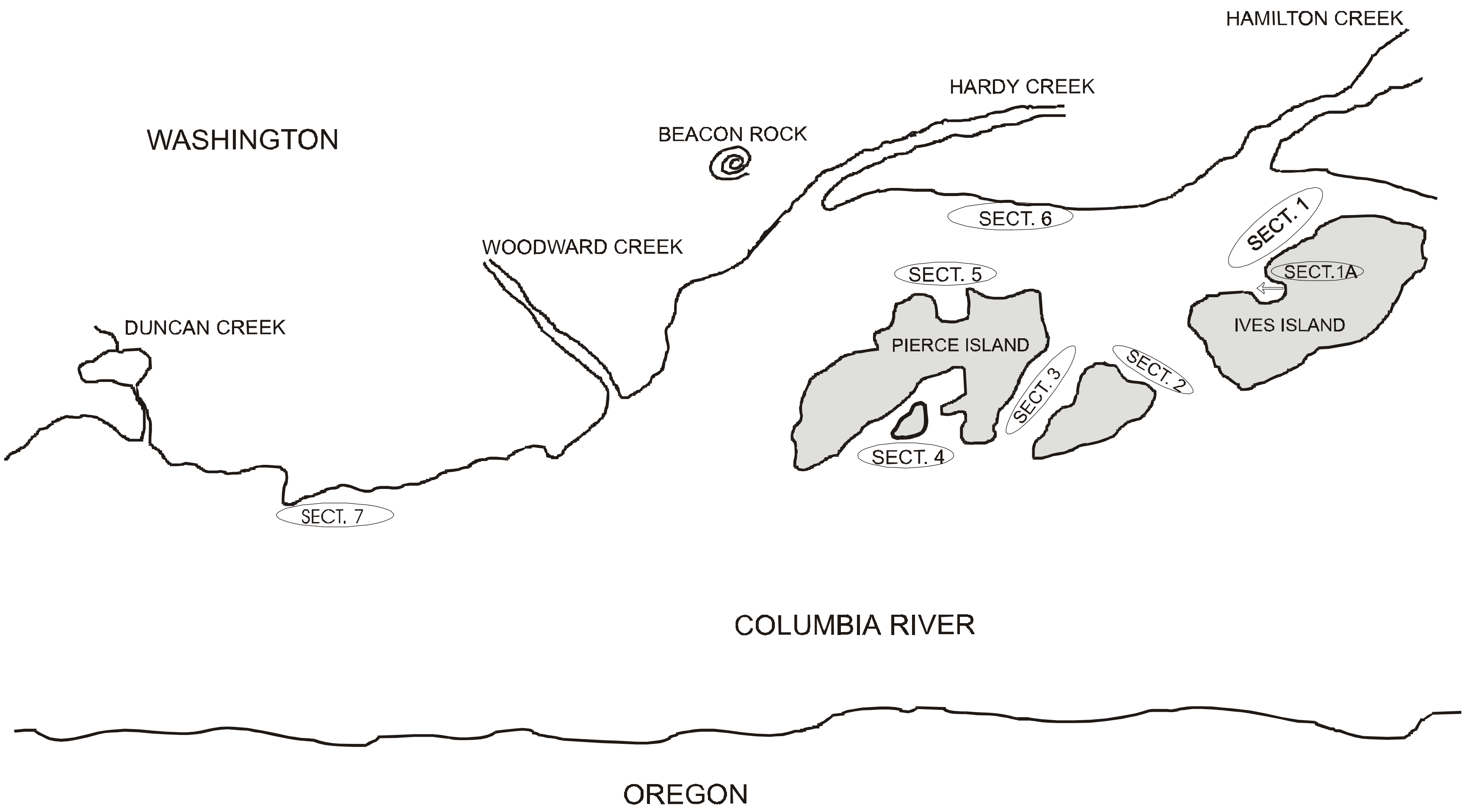

Figure 2. Location of juvenile sampling sections below Bonneville Dam, 2000.

Two types of gear were used to capture juvenile fish in the study area. Shorelines were fished with four-foot deep stick seines with one-eighth inch mesh in lengths of 18 and 28 feet. The sampling crew also employed a 100-foot long, ten-foot deep beach seine with one-eighth inch mesh. After the seines were set, they were immediately retrieved. In-water fishing time was approximately five minutes. Seines worked best in sections of the river that were free of snags and large obstructions and having moderate velocities. Captured fish were dip-netted into a five-gallon bucket containing the anesthetic MS-222. Once anesthetized, fish were identified by species, measured for fork length, examined for fin clips. Developmental stage of fry was also noted (e.g., yolk sac or button-up fry). Processing time was five to ten minutes per set. After data was collected, fish were returned to the site of capture. Beginning and ending times for each sampling period were recorded along with the number of sets fished and water temperatures. In addition, Bonneville Dam flows were noted and recorded for those periods when sampling occurred.

When unmarked upriver juvenile chinook were caught in the study area, the criterion used for differentiating chinook juveniles that were products of the study area from upriver natural production and hatchery releases was based on the length of the sampled fish. Chinook less than 50 mm were assumed to be products of the study area. This assumption is based on the fact that juvenile chinook emerge at a size range of 35-40mm, hatcheries above Bonneville Dam release chinook at sizes greater than 60 mm and wild upriver chinook juveniles do not begin migrating until they are larger than 60mm. As study area wild chinook grew in size the length criterion used to differentiate them from untagged upriver hatchery and wild production increased. This method was effective until the month of June when upriver smolts of approximately the same size as study area chinook began migrating into the study area. Although there is little natural chum production on the Columbia River above Bonneville Dam and no chum hatchery programs, it can not be determined whether chum captured in the study area were products of mainstem spawning since nearby Hamilton and Hardy creeks also produce chum.

In conjunction with juvenile sampling, entrapment surveys were made in low-lying areas surrounding the Ives/Pierce Island complex. Areas were surveyed to determine the number of juvenile fall chinook and chum salmon entrapped following decreases in Bonneville Dam discharge. A two-person crew made surveys three days a week while juvenile fish were present in the study area. Location of entrapments, the number of fish found entrapped and the rate of discharge from Bonneville Dam before and after each entrapment event was recorded.

RESULTS AND DISCUSSION

Adult study

Spawning of fall chinook and chum below Bonneville Dam was documented by counts of live fish, redds and post-spawning mortality (Table 1). Based on spawning ground surveys, initiation of spawning below Bonneville Dam for early-spawning tule stock and late spawning bright stock fall chinook salmon was set at 5 October and 29 October 1999, respectively. Initiation of spawning below Bonneville Dam for chum salmon was set at 5 November 1999.

Peak spawning for early-spawning tule stock and late spawning bright stock fall chinook salmon was determined to be 12 October and 9 November, respectively. Peak spawning for chum was set at 23 November. A total of 39 redds and 15 adults were observed at peak spawning for tules. Peak spawning for bright fall chinook saw 152 redds and 268 fish. 29 redds and 40 fish were observed at the time set for peak spawning for chum. The dates determined as the end of spawning were 26 October for tule fall chinook, 23 November for bright fall chinook and 21 December for chum. Chum spawning may have continued to occur after 21 December 2000 but by late-December high water and turbid river conditions made surveying difficult and spawning activity could no longer be observed.

No fall chinook redds were found or carcasses sampled below The Dalles and McNary dams. It appeared the areas surveyed below both dams had minimal spawning habitat. Although no redds and only one live fish was observed below the John Day Dam, seven fall chinook carcasses were found and there seemed to be areas below the John Day Dam where spawning could potentially occur. Below Bonneville Dam, fall chinook spawning times appear to be similar to other early and late-spawning stocks of fall chinook in the Columbia River. Below Bonneville Dam, chum spawning times appear to be similar to those observed for populations found in nearby Hardy and Hamilton creeks.

Locations of redds below Bonneville Dam were recorded using GPS waypoints. Figures 3, 4 and 5 show approximate locations of these redds. The majority of chum redds were observed below the mouth of Hamilton Creek. Locations of fall chinook redds were found where suitable aggregate and adequate flows existed, including areas in the main river channel between Ives and Pierce islands in water depths up to ten feet deep.

Below Bonneville Dam, fall chinook population estimates were made based on results of carcass tagging. A total of 366 fall chinook were tagged and 78 tags were recovered. Using the above numbers and incorporating them into the aforementioned Worlund technique, 1,012 returning fall chinook were estimated to have spawned below Bonneville Dam (Tables 2-3). It was estimated that 898 were of bright stock and 114 of tule stock. The bright fall chinook estimate should be

Table 1. Columbia River mainstem spawning ground surveys, 1999.

Below Bonneville Dam

Fall Chinook

Date	Redds	Live	Dead	Sampled	CWT recoveries	GSI samples
10/05/1999	9	18	6	6	0	0
10/08/1999	9	8	9	9	0	6
10/12/1999	39	15	13	13	1	6
10/15/1999	31	14	5	5	0	4
10/19/1999	45	6	5	4	0	0
10/22/1999	42	10	5	5	0	0
10/26/1999	30	18	4	4	0	0
10/29/1999	28	94	3	3	0	0
11/02/1999	124	230	4	4	0	0
11/05/1999	177	210	8	8	0	0
11/09/1999	152	268	71	71	0	0
11/12/1999	114	208	69	69	0	0
11/16/1999	92	199	111	99	2	0
11/19/1999	12	21	71	71	0	0
11/23/1999	25	35	84	84	1	0
11/30/1999	0	0	32	32	0	0
12/03/1999	0	0	0	0	0	0
12/07/1999	0	0	28	26	0	0
12/10/1999	0	0	0	0	0	0
12/14/1999	0	1	20	20	0	0
12/17/1999	0	0	0	0	0	0
12/21/1999	0	0	0	0	0	0
Total			549	533	4	16

Below Bonneville Dam

Chum

Date	Redds	Live	Dead	Sampled	CWT recoveries	GSI samples
11/02/1999	0	3	0	0	0	0
11/05/1999	5	1	0	0	0	0
11/09/1999	8	12	0	0	0	0
11/12/1999	5	7	0	0	0	0
11/16/1999	3	20	0	0	0	0
11/19/1999	1	9	0	0	0	0
11/23/1999	29	40	1	1	0	1
11/30/1999	2	18	1	1	0	1
12/03/1999	8	18	1	1	0	1
12/07/1999	1	6	5	4	0	4
12/10/1999	3	3	0	0	0	0
12/14/1999	1	7	2	2	0	0
12/17/1999	0	0	1	1	0	0
12/21/1999	0	0	2	2	0	0
Total			13	12	0	7

Below The Dalles Dam

Fall Chinook

Date	Redds	Live	Dead	Sampled	CWT recoveries	GSI samples
10/21/1999	0	0	0	0	0	0
11/04/1999	0	0	1-coho	1	0	0
12/02/1999	0	0	0	0	0	0
Total			1	1	0	0

Below John Day Dam

Fall Chinook

Date	Redds	Live	Dead	Sampled	CWT recoveries	GSI samples
10/20/1999	0	0	0	0	0	0
10/27/1999	0	0	0	0	0	0
11/03/1999	0	0	0	0	0	0
11/17/1999	0	1	0	0	0	0
11/24/1999	0	0	2	2	1	0
12/01/1999	0	0	2	2	0	0
12/08/1999	0	0	3	1	0	0
Total			7	5	1	0

Below McNary Dam

Fall Chinook

Date	Redds	Live	Dead	Sampled	CWT recoveries	GSI samples
10/28/1999	0	0	1-coho	1	0	0
11/18/1999	0	0	0	0	0	0
Total			1	1	0	0

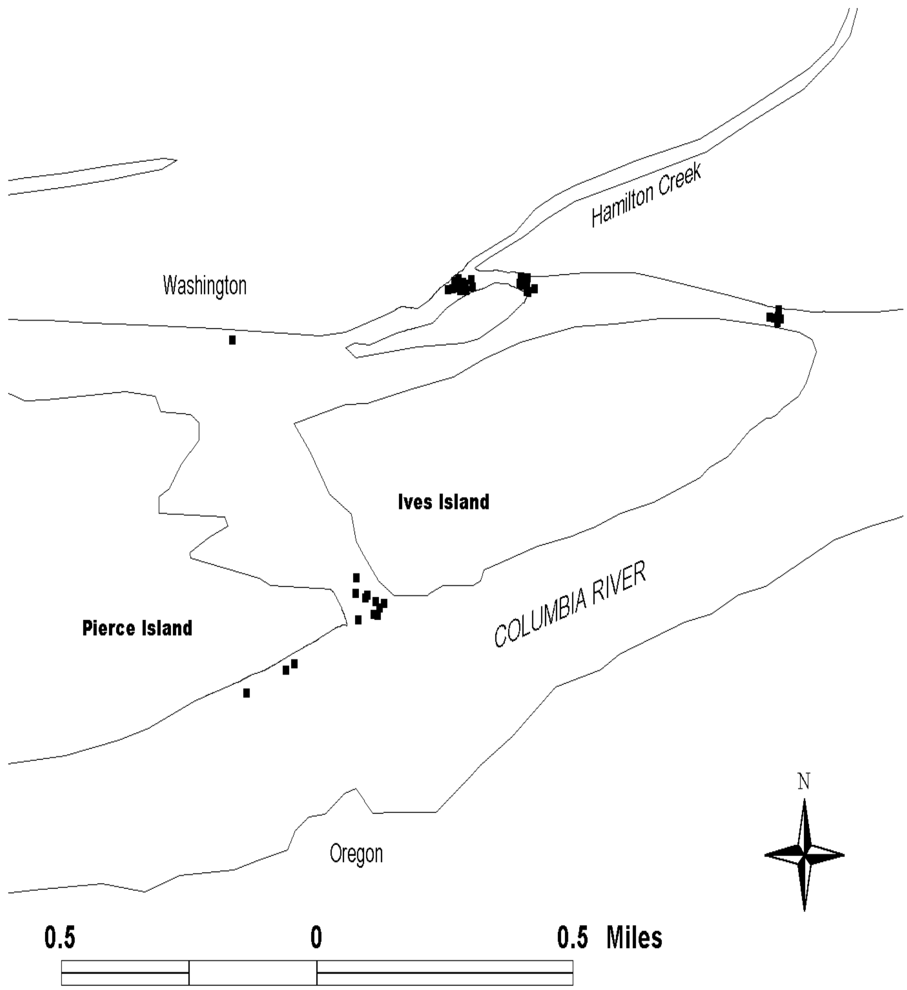

Figure 3. Location of tule chinook redds below Bonneville Dam, 1999.

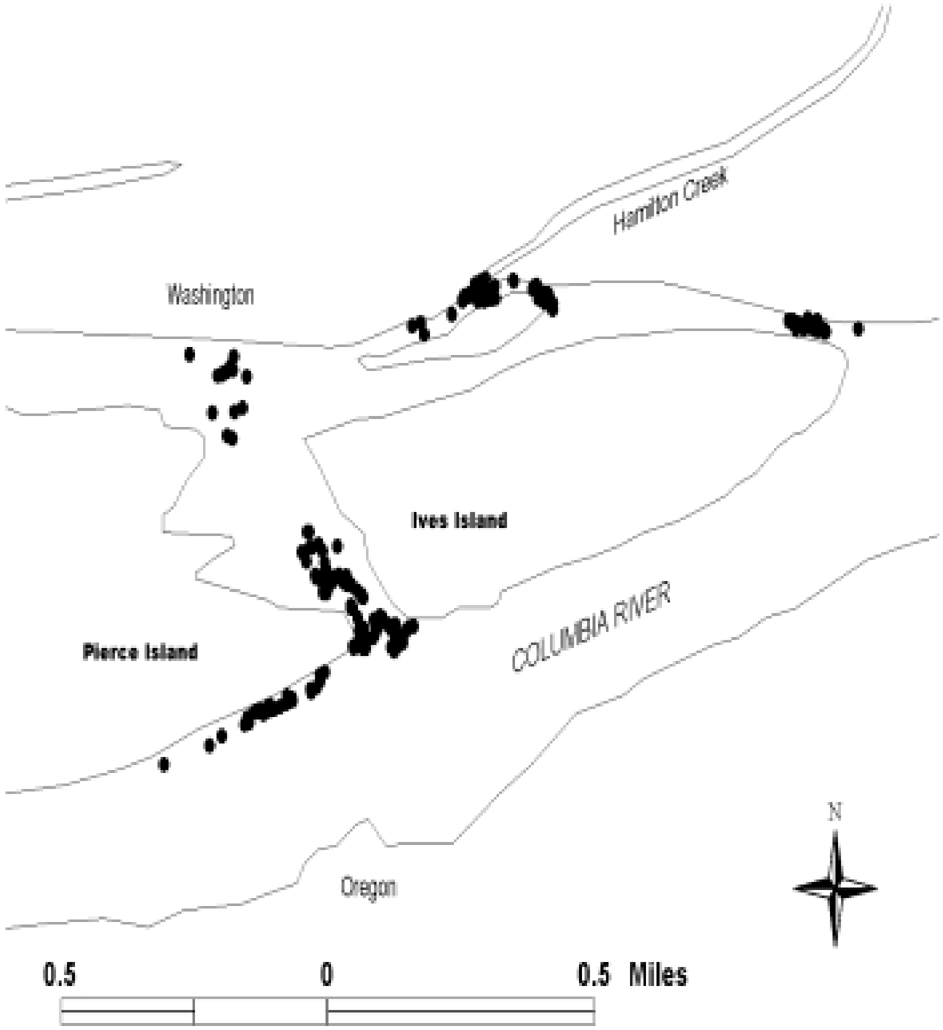

Figure 4. Location of upriver bright chinook redds below Bonneville Dam, 1999.

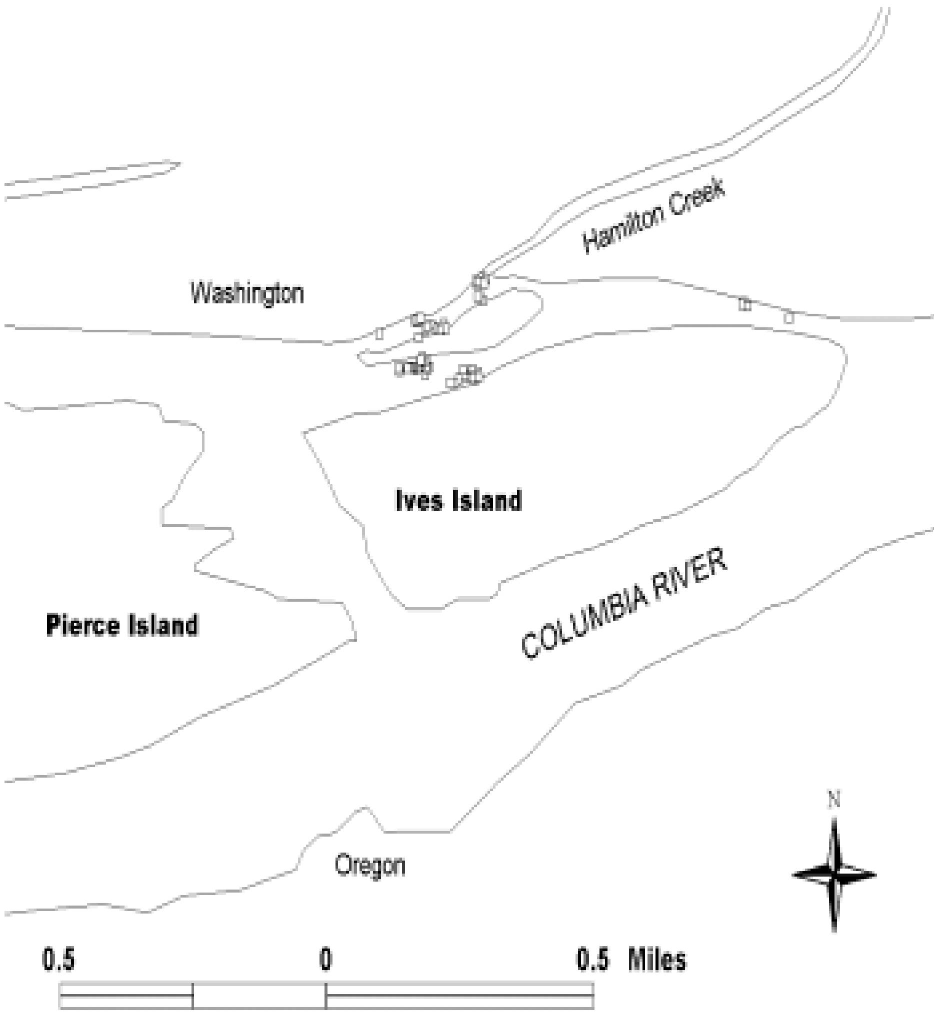

Figure 5. Location of chum redds below Bonneville Dam, 1999.

Table 2. Summary of the carcass tagging and used to estimate the population of fall chinook spawning in the Columbia River below Bonneville Dam, 1999.

				Tag recoveries by period										
Period	Date	Tag color	Number	2	3	4	5	6	7	8	9	10	11	12
1														
2	05-Oct	Orange Triangle	6	2	0	0	0	0	0	0	0	0	0	0
3	12-Oct	Red Triangle	13		0	0	0	0	0	0	0	0	0	0
4	19-Oct	Yellow Square	5			0	0	0	0	0	0	0	0	0
5	26-Oct	Yellow Triangle	5			2	0	1	2	0	0	0	0	0
6	02-Nov	Brown Square	4					0	0	0	0	0	0	0
7	09-Nov	Green Square	71						10	2	0	0	0	0
8	16-Nov	Yellow circle	99							28	2	1	0	0
9	23-Nov	Red Circle	84								6	3	1	0
10	30-Nov	Blue Square	32									7	1	0
11	07-Dec	Orange Square	26										9	1
12	14-Dec	Tan Square	20											0
	21-Dec	Red 1/2 Circle	1											

Table 3. Quantities used to calculate the total natural spawning population of fall chinook in the Columbia River below Bonneville Dam, 1999.

Worksheet A

i	Ti	Zi	Ri	Ri'	Ci	Mi	Pi	Ni	si	ui	Bi	~si	Di	si-T(i)
0											0.0000		0.0000	
1	6	0	0	2	6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
2	13	0	2	0	15	0.0000	0.1333	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
3	5	0	0	2	5	0.0000	0.0000	0.0000	0.4000	0.0000	7.0000	0.6325	11.0680	
4	5	0	2	3	7	2.0000	0.2857	7.0000	0.0000	1.0000	0.0000	0.0000	0.0000	
5	4	3	0	0	4	0.0000	0.0000	0.0000	3.2000	0.0000	924.0000	1.7912	515.8684	
6	71	2	1	12	72	12.6333	0.0139	924.0000	0.2229	0.0779	34.8041	0.4711	73.8714	
7	99	2	12	31	111	18.3871	0.1081	170.0000	0.5238	0.6526	126.9600	0.7237	175.4248	
8	84	3	30	10	114	55.2000	0.2632	209.7600	0.2564	0.5435	93.9077	0.5064	185.4520	
9	32	5	8	8	40	28.0000	0.2000	140.0000	0.3226	0.2857	13.8446	0.5658	24.3733	
10	26	2	11	9	37	16.7778	0.2973	56.4343	0.3462	0.6596	15.2727	0.5883	25.9586	
11	20	0	11	1	31	11.0000	0.3548	31.0000	0.0500	1.0000	0.0000	0.2236	0.0000	0.05
12	1	0	1	0	2	1.0000	0.5000	2.0000		1.0000		0.0000		
Total	366		79										1012.089	

Tule Chinook Pop. Est. -114.18
Bright Chinook Pop. Est. - 897.83

considered a minimum estimate since a number of returning fish were observed spawning in the deeper main channel areas where carcasses could not be recovered. There were too few chum carcasses tagged (11) and only one tag recovered therefore, this year’s adult chum population was based on the peak spawning count of 40 fish.

To assist in determining whether fish had successfully spawned, female carcasses were inspected for the presence of eggs. A total of 64 female bright fall chinook, 27 female tule fall chinook and 9 female chum carcasses were examined in the study area below Bonneville Dam. Body cavities contained few eggs and all carcasses appeared to be spawned out. Three female fall chinook carcasses were found below the John Day Dam and they appeared to be spawned out.

Vital statistics were developed to aid in determining stock origins of returning fish found spawning in the study areas. Vital statistics of fall chinook populations found below Bonneville and John Day dams in 1999 include age compositions, mean fork lengths, and sex ratios (Tables 4-6). Fall chinook populations sampled below the dams showed similarities in age classes with other early and late-spawning stocks found in the Columbia River.

Table 7 contains vital statistics of chum sampled below Bonneville Dam. In 1999, age composition statistics of chum sampled in the study area were similar to chum populations found in the lower Columbia River. For those populations, three and four-year-old fish were the predominant age classes.

To further assist in determining the stock origin of salmon found below the four dams, carcasses were sampled for fin clips and other external marks. A total of 538 fall chinook and 12 chum were sampled for marks below the four dams. Four carcasses were found to have adipose fin clips. All four chinook carcasses were recovered below Bonneville Dam and all contained coded-wire tags. Two of the four fish were bright fall chinook released as juveniles from Bonneville Hatchery’s Tanner Creek. Of the remaining two recoveries, one was a tule fall chinook released from Spring Creek National Fish Hatchery and one was a bright fall chinook released in the Snake River. No adipose-clipped chum were found.

GSI sampling of tule fall chinook and chum carcasses found below Bonneville Dam and fall chinook carcasses found below The Dalles and John Day dams provided too few samples to assist in determining stock origin of the returning spawners. Collection of the minimum sample size of 100 total samples for each population was not accomplished this year. A total of seven samples were collected from chum below Bonneville Dam, 16 from tule fall chinook below Bonneville Dam. There were no samples collected from fall chinook populations above Bonneville Dam. Since 1998, a grand total of 23 genetic samples have been collected from chum and 16 from tule fall chinook below Bonneville Dam. Fifteen genetic samples

Table 4. Estimated age composition, sex composition, and length of tule fall chinook salmon that spawned below Bonneville Dam, 1999.

Age	Number In Sample		% In Sample		Mean Length (cm)		Length Range (cm)	
	Males	Females	Males	Females	Males	Females	Males	Females
2	1	0	2.4	0.0	62	-	62	-
3	2	16	4.9	39.0	78	72	70-85	68-81
4	11	11	26.8	26.8	84	79	74-99	71-92
5	0	0	0.0	0.0	-	-	-	-
Total	14	27	34.0	66.0				

Table 5. Estimated age composition, sex composition, and length of bright fall chinook salmon that spawned below Bonneville Dam, 1999.

Age	Number In Sample		% In Sample		Mean Length (cm)		Length Range (cm)	
	Males	Females	Males	Females	Males	Females	Males	Females
2	0	0	0.0	0.0	-	-	-	-
3	9	10	10.0	11.0	72	73	60-88	59-86
4	15	52	16.7	57.8	88	84	76-106	67-97
5	2	2	2.2	2.2	112	99	105-119	98-99
Total	26	64	29.0	71.0				

Table 6. Estimated age composition, sex composition, and length of bright fall chinook salmon that spawned below John Day dam, 1999.

Age	Number In Sample		% In Sample		Mean Length (cm)		Length Range (cm)	
	Males	Females	Males	Females	Males	Females	Males	Females
2	0	0	0.0	0.0	-	-	-	-
3	0	1	0.0	20.0	-	80	-	80
4	2	2	40.0	40.0	89	88	87-91	83-93
5	0	0	0.0	0.0	-	-	-	-
Total	2	3	40.0	60.0				

Table 7. Estimated age composition, sex composition, and length of chum salmon that spawned below Bonneville Dam, 1999.

Age	Number In Sample		% In Sample		Mean Length (cm)		Length Range (cm)	
	Males	Females	Males	Females	Males	Females	Males	Females
2	0	0	0.0	0.0	-	-	-	-
3	1	6	8.3	50.0	94	74	94	69-79
4	2	3	16.7	25.0	80	74	77-83	70-77
5	0	0	0.0	0.0	-	-	-	-
Total	3	9	25.0	75.0				

have been collected from chinook above Bonneville Dam. Below Bonneville Dam, bright fall chinook were sampled for GSI data by WDFW in 1996 and 1997. Analysis of 142 samples showed relatively small genetic differences between the below Bonneville Dam samples and samples taken from other Columbia River late-spawning stock fall chinook. The analysis suggests, bright chinook spawning below Bonneville Dam are genetically similar to other bright fall chinook populations found in the Columbia River such as those found in the Hanford Reach and at Bonneville Hatchery.

Juvenile study

Hatching and emergence times for 1999 brood salmon below Bonneville Dam are contained in Table 8. Based on required temperature units that predict early life history and Columbia River water temperatures taken in the study area, hatching of tule fall chinook eggs was estimated to have occurred from approximately 14 November to 22 December 1999. Hatching of bright fall chinook was estimated to have occurred from 22 December 1999 to 11 March 2000. Hatching of chum was estimated to have occurred from 28 January to 11 April 2000.

It was discovered that the water beneath the areas where the majority of tule fall chinook and chum spawning occurred are influenced by geothermal activity. This subsurface activity increased the water temperature in the redds by approximately two degrees Celsius. As a result, an additional two degrees Celsius was factored into the estimated emergence times of tule fall chinook and chum.

Emergence of tule fall chinook began on 24 December 1999 and continued through 22 February 2000. Peak emergence of tules occurred 27 January. Emergence of chum below Bonneville Dam began 3 February and continued through 8 April. Peak emergence of chum took place 13 March 2000. The areas where bright fall chinook spawned were not subject to the above warming phenomenon and as a result, emergence was more consistent with temperature readings from USFWS' Ives Island gauge. Emergence of bright fall chinook began approximately 5 April and continued through 10 May. Peak emergence of bright fall chinook occurred 14 April 2000.

Sampling for post-emergent fry took place in locations identified in Figure 2. Based on emergence estimates juvenile sampling began 26 January 2000. Sampling was terminated 11 July after it appeared that the majority of the study area fish had left the area. A total of 12,020 juvenile chinook and 167 juvenile chum were sampled. Catch rates of gear used to capture juvenile chinook are contained in Table 9. Results of juvenile chum sampling are found in Table 10. The majority of juvenile chum were caught in sections one and six of the study area. Section one is where the majority of chum spawning took place in 1999. The first chum fry caught

Table 8. Columbia River water temperature (°F) and temperature units (° C) below Bonneville Dam, 1999-2000.

(Temperatures through June 20, 2000 collected from USFWS Ives Island temperature gauge.)

	OCTOBER		NOVEMBER		DECEMBER		JANUARY		FEBURARY		MARCH		APRIL		MAY		JUNE	
DAY	TEMP (F)	TU's (C)	TEMP (F)	TU's (C)	TEMP (F)	TU's (C)	TEMP (F)	TU's (C)	TEMP (F)	TU's (C)	TEMP (F)	TU's (C)	TEMP (F)	TU's (C)	TEMP (F)	TU's (C)	TEMP (F)	TU's (C)
1	63	17	48	9	48	9	41	5	37	3	39	4	45	7	50	10	57	14
2	61	16	50	10	48	9	41	5	37	3	39	4	45	7	50	10	57	14
3	61	16	52	11	48	9	41	5	37	3	39	4	46	8	50	10	58	14
4	61	16	52	11	48	9	41	5	37	3	39	4	46	8	52	11	58	15
5	61	16	52	11	46	8	41	5	37	3	39	4	46	8	52	11	58	15
6	61	16	52	11	46	8	41	5	37	3	39	4	46	8	52	11	58	15
7	61	16	52	11	46	8	41	5	37	3	39	4	46	8	52	11	58	15
8	61	16	52	11	46	8	41	5	37	3	39	4	46	8	52	11	58	15
9	61	16	52	11	46	8	41	5	37	3	41	5	46	8	52	11	59	15
10	59	15	52	11	46	8	41	5	37	3	41	5	48	9	52	11	58	14
11	59	15	52	11	46	8	41	5	37	3	41	5	48	9	52	11	58	14
12	59	15	52	11	46	8	39	4	39	4	41	5	48	9	52	11	58	14
13	59	15	52	11	45	7	39	4	39	4	41	5	48	9	52	11	58	14
14	59	15	52	11	45	7	39	4	39	4	41	5	48	9	54	12	58	14
15	59	15	52	11	45	7	39	4	39	4	41	5	48	9	54	12	59	15
16	57	14	52	11	45	7	39	4	39	4	41	5	48	9	54	12	59	15
17	55	13	52	11	45	7	39	4	39	4	43	6	50	10	54	12	60	16
18	52	11	50	10	45	7	39	4	39	4	43	6	50	10	54	12	61	16
19	54	12	50	10	45	7	39	4	39	4	43	6	50	10	54	12	60	16
20	54	12	50	10	45	7	39	4	39	4	43	6	50	10	54	12	60	16
21	55	13	50	10	45	7	39	4	39	4	43	6	50	10	55	13		
22	57	14	50	10	45	7	39	4	39	4	43	6	50	10	55	13		
23	55	13	50	10	43	6	39	4	39	4	43	6	50	10	56	13		
24	57	14	50	10	43	6	39	4	39	4	43	6	50	10	57	14		
25	57	14	50	10	43	6	39	4	39	4	43	6	50	10	57	14		
26	55	13	50	10	43	6	39	4	39	4	45	7	50	10	57	14		
27	54	12	50	10	43	6	39	4	39	4	45	7	50	10	57	14		
28	54	12	50	10	43	6	37	3	39	4	45	7	50	10	57	14		
29	54	12	48	9	43	6	37	3	39	4	45	7	50	10	57	14		
30	54	12	48	9	43	6	37	3			45	7	50	10	57	14		
31	54	12			41	5	37	3			45	7			57	14		
Total TUs	--	438	--	312	--	223	--	131	--	105	--	168	--	273	--	374.2	--	0
Mean Temp.	57.4	14.1	50.7	10.4	44.9	7.2	39.6	4.2	38.5	3.6	41.8	5.4	48.4	9.1	53.7	12.1	39.0	15.3

REQUIRED TEMPERATURE UNITS (TU'S)

FALL CHINOOK	(°C)
EYE OUT	250
HATCHING	500
EMERGENCE	1000
CHUM	
EYE OUT	400
HATCHING	600
EMERGENCE	800

CUMULATIVE TU'S (°C) SINCE INITIATION AND END OF SPAWNING

	EVENT		EYED OUT		HATCHING		EMERGENCE		
FALL CHINOOK		DATE	DAY	TU'S	DAY	TU'S	DAY	TU'S	1st 2°C*
TULES	BEGIN SPAWNING	10/5	10/23	254	11/14	506	1/26	1001	12/24
	PEAK SPAWNING	10/19	11/8	251	12/4	503	3/17	1004	1/27
	END SPAWNING	10/29	11/21	250	12/22	504	4/5	1004	2/22
BRIGHTS	BEGIN SPAWNING	10/29	11/29	250	12/22	504	4/5	1004	2/22
	PEAK SPAWNING	11/5	11/29	251	1/4	498	4/14	1004	3/9
	END SPAWNING	11/30	1/06	249	3/11	503	5/10	1004	4/12
CHUM									
	BEGIN SPAWNING	11/5	12/10	402	1/20	602	3/10	802	2/3
	PEAK SPAWNING	11/23	1/26	402	3/16	598	4/14	803	3/13
	END SPAWNING	12/14	3/13	399	4/11	598	5/2	803	4/9

* Temperature plus two degrees Celsius.

Table 9. Catch rates of juvenile chinook caught with stick and beach seines below Bonneville Dam, 2000.

Week	Date	# chinook	# stick sets	# caught in stick	# beach sets	# caught in beach	chinook per stick	chinook per beach
1	26-Jan	27	2	11	3	16	5.5	5.3
2	31-Jan	7	4	0	6	7	0.0	1.2
2	01-Feb	3	3	0	1	3	0.0	3.0
3	07-Feb	7	3	7	4	0	2.3	0.0
3	10-Feb	1	2	0	6	1	0.0	0.2
4	14-Feb	53	2	15	7	38	7.5	5.4
4	18-Feb	9	3	0	5	9	0.0	1.8
5	22-Feb	12	2	12	5	0	6.0	0.0
5	24-Feb	14	3	12	5	1	4.0	0.2
6	28-Feb	28	2	3	5	25	1.5	5.0
6	02-Mar	36	3	13	7	23	4.3	3.3
7	07-Mar	31	2	6	5	25	3.0	5.0
7	10-Mar	28	1	3	4	25	3.0	6.3
7	11-Mar	247	0	0	4	247	0.0	61.8
8	14-Mar	24	2	16	5	8	8.0	1.6
8	17-Mar	43	2	0	7	43	0.0	6.1
9	21-Mar	93	3	48	6	45	16.0	7.5
9	24-Mar	38	4	0	5	38	0.0	7.6
10	28-Mar	107	1	0	6	107	0.0	17.8
10	31-Mar	82	1	0	8	82	0.0	10.3
11	04-Apr	387	2	0	6	387	0.0	64.5
11	07-Apr	229	1	0	7	229	1.0	32.7
12	11-Apr	159	1	1	8	158	1.0	19.8
12	14-Apr	221	1	0	8	221	0.0	27.6
13	18-Apr	194	1	43	7	151	43.0	21.6
13	21-Apr	256	1	49	6	207	49.0	34.5
14	25-Apr	207	2	132	9	75	66.0	8.3
14	28-Apr	398	2	141	8	257	70.5	32.1
15	02-May	519	2	192	6	327	96.0	54.5
15	05-May	378	1	104	7	274	104.0	39.1
16	10-May	437	2	233	8	204	116.5	25.5
17	16-May	263	2	66	6	197	33.0	32.8
18	23-May	390	2	227	5	163	113.5	32.6
20	06-Jun	350	2	205	5	145	102.5	29.0
21	13-Jun	213	2	97	5	116	48.5	23.2
22	20-Jun	135	6	38	6	97	6.3	16.2
23	27-Jun	524	2	19	6	505	9.5	84.2
24	05-Jul	205	0	0	5	205	0.0	41.0
25	11-Jul	84	0	0	5	84	0.0	16.8

Table 10. Fork length information of juvenile chum sampled below Bonneville Dam, 2000.

Date	Number	Fork length range (mm)	Mean Fork Length (mm)
22-Feb	1	36.0	36.0
24-Feb	3	37.0 - 39.0	39.0
28-Feb	2	35.0 - 37.0	36.0
02-Mar	1	39.0	39.0
07-Mar	3	36.0 - 40.0	38.0
10-Mar	4	38.0 - 41.0	40.0
14-Mar	5	35.0 - 42.0	31.0
17-Mar	1	40.0	40.0
21-Mar	37	36.0 - 42.0	38.0
24-Mar	6	37.0 - 41.0	47.0
28-Mar	9	36.0 - 41	39.0
31-Mar	2	43.0 - 49.0	46.0
04-Apr	28	37.0 - 45.0	41.0
07-Apr	10	38.0 - 56.0	48.0
11-Apr	27	37.0 - 47.0	40.0
14-Apr	4	39.0 - 49.0	46.0
18-Apr	5	38.0 - 55.0	43.0
21-Apr	15	35.0 - 44.0	39.0
25-Apr	1	39.0	39.0
05-May	1	40.0	40.0
02-Jun	1	59.0	59.0
13-Jun	1	69.0	69.0
Total	167	35.0 - 69.0	42.4

and sampled was on 22 February and was 36.0 mm, fork length. The last juvenile chum was caught on 13 June and was 69.0 mm in length. Chum fry ranged in size from 35.0 mm to 69.0 mm in length, mean length was 42.4 mm. The small number of chum observed and sampled may be due to the fact that juvenile chum are very elusive and will often swim into the substrate when sensing danger. In addition, chum spend little time rearing in freshwater, migrating soon after emergence.

Results of the below Bonneville Dam juvenile chinook sampling are contained in Table 11. The table shows weekly changes in the length distribution of juveniles sampled in the study area. Recently emerged fish (less than 50 mm in length) were present in the sample catch from 26 January to 5 July. The first chinook were caught and sampled on 26 January and ranged in fork length from 40.0 to 47.0 mm, suggesting this group had emerged in December 1999. These fish were most likely progeny of tule fall chinook that began spawning in the early part of October 1999. Sampling data suggests that juvenile tule migration was likely complete by late March.

Based on length frequency data, there appears to be both juvenile tule and bright fall chinook occupying the study area during the month of March. Peak catch of fish that were 50 mm or less in fork length was 12 May. Until mid June, when wild upriver juvenile chinook began appearing in the sample, juvenile chinook found in the study area that were less than 60 mm in length were assumed to be production from the study area. This assumption was based on Columbia River fish passage data that showed upriver chinook hatchery releases, which consisted mainly of juvenile chinook larger than 60 mm in length, occurred through the middle of June.

As water temperatures increased below Bonneville Dam, the mean fork length of chinook in the study area also increased. From 7 April to 13 June mean fork length increased from 45.0 mm to 67.0 mm, a growth rate of 0.33 mm/day. Wild juvenile chinook reared below Bonneville Dam until they attained a size of approximately 60 to 80 mm in length, at which time they began migrating from the area. Chinook found in samples that were larger than 80 mm in fork length were associated with upriver hatchery releases since adipose-clipped chinook greater than 80 mm in length would often appear in the sample after upriver hatchery releases. Peak migration of study area fall chinook occurred from late May through the early part of June. By 7 July juvenile chinook less than 60 mm in length represented only five percent of the population below Bonneville Dam, signaling the end of 1999 brood fall chinook rearing around the Ives and Pierce islands.

Table 11. Fork length distribution of juvenile chinook sampled below Bonneville Dam, 2000.

				Number of chinook in millimeters								Mean length	% chf	
Week	Date	Total	Range	30-39	40-49	50-59	60-69	70-79	80-89	90-100	> 100	chf < 100 mm	< 60 mm	61- 100 mm
1	26-Jan	27	40-47	-	27	-	-	-	-	-	-	44	100	0
2	31-Jan	7	38-46	1	6	-	-	-	-	-	-	43	100	0
2	01-Feb	3	44-125	-	2	-	-	-	-	-	1	44	50	50
3	07-Feb	7	44-51	-	6	1	-	-	-	-	-	47	100	0
3	10-Feb	1	45	-	1	-	-	-	-	-	-	45	100	0
4	14-Feb	53	36-154	1	31	8	-	-	-	-	13	47	75	25
4	17-Feb	9	36-128	1	4	2	-	-	-	-	2	47	78	22
5	22-Feb	12	39-57	1	3	8	-	-	-	-	-	51	100	0
5	25-Feb	14	50-57	-	-	14	-	-	-	-	-	54	100	0
6	28-Feb	28	39-58	1	4	23	-	-	-	-	-	52	100	0
6	02-Mar	36	37-113	1	3	30	-	-	-	-	2	53	94	6
7	07-Mar	31	37-130	2	12	13	-	-	-	-	4	49	87	13
7	10-Mar	28	39-135	1	2	9	6	3	-	-	7	59	43	57
8	14-Mar	24	35-72	9	10	4	1	-	-	-	-	44	96	4
8	17-Mar	43	39-75	4	9	5	15	10	-	-	-	59	42	58
9	21-Mar	93	34-131	39	24	3	13	12	-	-	2	49	71	29
9	24-Mar	38	37-75	3	9	4	18	4	-	-	-	57	42	58
10	28-Mar	107	33-77	15	45	12	19	14	-	-	2	51	67	33
10	31-Mar	82	38-82	1	7	6	34	33	1	-	-	66	17	83
11	04-Apr	387	36-131	49	228	28	29	47	5	-	1	49	79	21
11	07-Apr	229	35-84	34	165	17	5	6	2	-	-	45	94	6
12	11-Apr	159	32-138	8	107	6	5	23	8	-	2	51	76	24
12	14-Apr	221	37-135	26	128	12	6	31	16	-	2	51	75	25
13	18-Apr	194	36 - 83	42	135	12	1	1	3	-	-	44	97	3
13	21-Apr	256	35 - 136	40	194	9	1	2	2	-	8	44	95	5
14	25-Apr	207	36 - 89	33	138	17	3	4	8	1	3	45	91	9
14	28-Apr	398	34 - 105	70	248	53	-	5	18	3	1	47	93	7
15	02-May	519	32 - 95	81	311	117	4	1	4	1	-	46	98	2
15	05-May	378	32-134	72	170	127	7	1	-	-	1	46	98	2
16	09-May	437	33-95	62	189	137	36	2	6	5	-	49	89	11
16	12-May	1710	33-80	342	753	364	51	-	-	-	-	47	96	4
17	16-May	263	33-88	41	75	109	33	3	2	-	-	50	86	14
17	19-May	1015	33-80	112	348	355	190	10	-	-	-	52	80	20
18	23-May	390	32-120	48	88	63	96	32	22	22	19	57	51	49
18	26-May	946	35-99	24	277	277	212	104	38	9	-	57	61	39
19	31-May	518	35-107	10	109	102	137	87	34	31	8	63	43	57
19	02-Jun	545	35-92	22	120	153	109	98	38	5	-	60	54	46
20	06-Jun	350	34-104	8	40	51	59	127	59	4	2	67	28	72
20	09-Jun	670	39-92	7	74	168	121	194	114	7	-	67	37	63
21	13-Jun	213	38-100	4	24	57	41	42	35	9	1	66	40	60
21	16-Jun	360	35-96	-	50	94	90	68	47	11	-	65	40	60
22	20-Jun	135	43-106	-	1	17	63	34	10	8	2	69	13	87
22	23-Jun	648	40-100	-	19	78	214	207	104	19	2	70	15	85
23	27-Jun	524	44-111	-	3	49	103	160	143	61	5	76	10	90
23	30-Jun	204	48-104	-	2	20	71	63	41	4	-	72	11	89
24	03-Jul	205	43-99	-	3	14	56	35	79	18	-	76	8	92
24	07-Jul	203	49-99	-	-	10	108	55	26	2	-	70	5	95
25	11-Jul	84	61-108	-	-	-	26	21	28	8	1	78	0	100
Totals:		13,011		1,214	4,104	2,838	1,983	1,348	893	229	91		63	37

It is difficult to say whether variations in Bonneville Dam discharge had any affect on migration timing of juveniles from the study area. Fluctuations in flow did have an impact on the sampling crew's ability to fish for juvenile salmon below the dam. Access to sampling areas within the study area changed with fluctuations in flow through the islands below Bonneville Dam and consequently sampling locations and gear changed in order to catch juvenile fish. In addition, it appears variations in flow may have had little effect on the ability of upriver migrating fish to gain access to the Ives and Pierce Island migration. Regardless of flow conditions, migrating fish from upriver locations found their way into the island area from the main channel. Marked fish were present in the sample after hatchery releases and during the upriver wild chinook migration. It appeared that the upriver fish spent little time in the study area before continuing downriver.

To assist in determining stock composition of juvenile chinook using the rearing areas below Bonneville Dam, sampled fish were examined for marks. Hatchery adipose-clipped juveniles were helpful in determining stock composition within the study area since they could be easily differentiated from the study area's wild fish by the presence of fin clips. The marked fish were also usually larger in size than the study area fish and this allowed samplers to identify the untagged component of marked releases by their relatively large size. Numbers and mean lengths of marked juvenile chinook are presented in Table 12.

From February through the end of May, marks and size of fish could easily distinguish study area chinook from upriver chinook smolts. After May, the majority of adipose-clipped chinook continued to be larger than study area chinook but some marked juveniles, which probably were part of the Hanford Reach wild population, were in the same size range as study area fish. During this period, the generally smaller unmarked migrating upriver wild chinook could not be distinguished from chinook rearing in the study area.

Since no chum hatcheries exist above the dams and nearby Hardy Creek and Hamilton Creek chum are not fin marked for assessment purposes, no marked chum were observed in the juvenile sampling. This being the case, chum from nearby creeks could not be differentiated from the population found spawning in the Columbia River.

Surveys to investigate entrapment of juvenile salmon in shallow water areas below Bonneville Dam began the first week of March 2000 and were completed 27 June 2000. Table 13 documents known entrapment events. All entrapped fish that were not mortalities were liberated into the river. There appears to be a relationship between sudden decreases in flows and the entrapment of juvenile fish rearing in the study area. The surrounding areas where the entrapments occurred are home to a large number of birds e.g. gulls and herons and evidence of their presence in the area was observed after river flows dropped.

Table 12. Adipose fin clipped fall chinook sampled below Bonneville Dam, 2000.

Week	Date	Number of marks	Fork Length (mm)	Mean length	Total chinook sampled	% of sample marked
1	26-Jan				27	
2	31-Jan				7	
2	01-Feb				3	
3	07-Feb				7	
3	10-Feb				1	
4	14-Feb				53	
4	18-Feb				9	
5	22-Feb				12	
5	24-Feb				14	
6	28-Feb				28	
6	02-Mar				36	
7	07-Mar				31	
7	10-Mar				28	
7	11-Mar	4	2@60, 62, 64	62	247	1.6
8	14-Mar				24	
8	17-Mar				43	
9	21-Mar	2	71,131	101	93	2.2
9	24-Mar				38	
10	28-Mar				107	
10	31-Mar	1	77	77	82	1.2
11	04-Apr				387	
11	07-Apr				229	
12	11-Apr				159	
12	14-Apr				221	
13	18-Apr				194	
13	21-Apr				256	
14	25-Apr				207	
14	28-Apr	1	80	80	398	0.3
15	02-May				519	
15	05-May	1	134	134	378	0.3
16	10-May				437	
16	12-May				308	
17	16-May	2	79, 87	83	263	0.8
17	19-May				452	
18	23-May	4	77, 97, 98, 101	93	390	1.0
18	26-May	3	80, 82, 87	83	383	0.8
19	31-May	5	80,86,89,93,95	89	518	1.0
19	02-Jun				305	
20	06-Jun	3	79, 80, 89	83	350	0.9
20	09-Jun	2	77, 88	83	280	0.7
21	13-Jun	1	100	100	213	0.5
21	16-Jun				211	
22	20-Jun	1	104	104	135	0.7
22	23-Jun				358	
23	27-Jun	4	89, 92, 95, 100	94	524	0.6
23	30-Jun				285	
24	05-Jul	4	88, 92, 93, 95	92	205	2.0
24	07-Jul	1	87	87	201	0.5
25	11-Jul	3	85, 2@94	91	84	3.6
Total		42			9,862	0.4

Table 13. Juvenile chum and fall chinook salmon found entrapped below Bonneville Dam, 2000.

Date	Location (section)	Hour entrapment observed	Flow at time of sample (kcfs)	Approximate time of entry into entrapment Date, time	Flow at time of entry (kcfs)	# of live chum in entrapments	# of dead chum in entrapments	# of live chinook in entrapments	# of dead chinook in entrapments	Mean size (mm) (fork length)	Size (mm) range (fork length)
3/07/00	3	1200	218	3/06, 0800	229	0	0	0	1	54.0	54.0
3/14/00	3	1400	200	3/13,1600	215	0	0	0	1	72.0	72.0
3/21/00	3	1400	165	3/21,0900	210	0	0	0	11	39.6	35.0-47.0
3/21/00	1	1200	187	3/21,0900	210	0	4	0	0	40.3	39.0-42.0
3/24/00	3	1200	221	3/24, 0200	229	0	0	1	0	38.0	38.0
3/25/00	3	1500	188	3/24, 2100	228	0	0	10	0	52.4	36.0-77.0
3/28/00	3	1500	175	3/25, 1900	206	0	0	85	0	55.6	39.0-82.0
3/31/00	3	1300	224	3/30,0800	231	0	0	2	0	58.5	39.0-78.0
4/04/00	4	1200	173	4/04, 0900	201	0	0	3	0	41.0	37.0-44.0
4/04/00	4	1200	173	4/04, 0900	201	0	0	0	2	38.5	37.0-40.0
4/11/00	5	1230	243	4/11, 0400	279	0	0	514	0	43.6	39.0-48.0
4/11/00	5	1230	243	4/11, 0400	279	0	0	0	6	72.4	58.0-82.0
4/11/00	5	1230	243	4/11, 0400	279	3	0	0	0	44.3	43.0-46.0
4/18/00	5	1230	304	4/15, 1600	332	0	0	0	10	43.6	40.0-46.0
4/28/00	5	1400	288	4/27, 2400	314	0	0	187	0	52.9	39.0-91.0
5/02/00	5	1350	292	5/02, 0800	332	0	0	16	0	47.6	39.0-93.0
5/12/00	5	1230	282	5/12, 0700	295	0	0	205	2	49.7	40.0-88.0
5/13/00	5	1300	232	5/13, 0700	282	0	0	36	0	50.5	39.0-63.0
5/16/00	1	1300	237	5/16, 0300	324	0	0	1	1	39.0	39.0
5/19/00	1	1500	246	5/19, 0300	290	0	0	1	9	39.3	35.0-45.0
5/20/00	5	1400	236	5/19, 2100	262	0	0	198	1	52.9	38.0-64.0
5/31/00	7	1300	244	5/30, 2100	270	0	0	0	1	59.0	59.0
5/31/00	5	1330	244	5/30, 2100	270	0	0	2	0	53.0	44.0-62.0
Total						3	4	1262	46		

In order to determine a juvenile to adult survival rate for wild fall chinook found below Bonneville Dam, we are investigating the possibility of coded-wire tagging a portion of the population. Similar tagging projects performed by WDFW show that the timing of such work on wild fall chinook is critical. Coded-wire tagging needs to be done within a relatively small time frame. WDFW found that it was necessary to begin tagging wild juvenile fall chinook after at least half the captured fish were large enough ($\geq$ 47 mm fork length) to receive a full length coded-wire tag, but before smoltification occurred. For our project, additional concerns include the necessity to capture juvenile chinook from areas around the islands that are free of smolts from early upriver hatchery releases and to terminate the operation before the month of June, when the upriver fall and summer chinook releases and wild chinook migration occurs. The time period that the project would be likely looking at to meet the above criterion is from the month of April to the middle of the month of June.

In FY 2000, we began determining the feasibility of capturing large numbers of juveniles from areas below Bonneville Dam that were least likely impacted by upriver releases. In the spring of 2000, our sampling showed that naturally produced fall chinook in the study area did not attain the 50% minimum fork length criterion until 9 May. By the beginning of June it appears the catch consisted of a mix of production from the study area and upriver migrants. A total of 2,800 juvenile fall chinook were caught during this period. With more effort and the prospect of earlier emergence, our catch of juvenile fall chinook should increase in the spring of 2001.

Since survival rate of fall chinook spawning and rearing below Bonneville Dam is unknown, it is difficult to determine the number of coded-wire tags necessary to estimate smolt to adult survival rate. Typically, a project would try to tag as many fish as possible. WDFW's goal for coded-wire tagging wild fall chinook in the Hanford Reach of the Columbia River was 200,000 fish. Because the population below Bonneville Dam is far smaller than the Hanford Reach population, a goal of 200,000 fish would not be feasible. Initially, our goal will be to coded-wire tag 10,000 juvenile fall chinook in the spring of 2001.

SUMMARY AND CONCLUSIONS

A total of 538 adult fall chinook and 12 chum were sampled below Bonneville, The Dalles, John Day and McNary dams in 1999. Peak redd counts below Bonneville Dam in 1999 for tule and bright fall chinook were 45 and 177, respectively. The peak redd count below Bonneville Dam for chum was 29. Peak spawning times below Bonneville Dam for tule and bright stock fall chinook were 12 October and 9 November, respectively. Peak spawning time for chum occurred 23 November. There were estimated to be a total of 1,012 fall chinook spawning below

Bonneville Dam in 1999. The 1999 adult chum population below Bonneville Dam was estimated to be 40 spawners.

Temperature unit data suggests that below Bonneville Dam 1999 brood tule fall chinook emergence began on 24 December 1999 and ended 22 February 2000, with peak emergence occurring 27 January 2000. 1999 brood bright fall chinook emergence began on 5 April and ended 10 May, with peak emergence occurring 14 April 2000. 1999 brood juvenile chum emergence below Bonneville Dam began 3 February 2000 and continued through 8 April 2000. Peak chum emergence below Bonneville Dam took place 13 March. A total of 13,011 juvenile chinook and 167 juvenile chum were sampled in the study area below Bonneville Dam. Juvenile chum migrated from the study area in the 40-50 mm fork length range. Peak migration occurred during the month of April. Results of juvenile chinook sampling corroborates the temperature unit estimate of peak emergence of 1999 brood fall chinook and suggests migration from rearing areas took place from late May through June 2000 when juvenile fall chinook were in the 60 to 80 mm fork length size range. Adult and juvenile sampling below Bonneville Dam provided information to assist in determining the stock of fall chinook and chum spawning and rearing below Bonneville Dam. Based on observed spawning time, adult age and sex composition, previous GSI analysis, juvenile emergence timing, juvenile migration timing and juvenile size at the time of migration, it appears fall chinook using the area below Bonneville Dam are a mix of early-spawning tule stock and late-spawning bright stock fall chinook. Determination of stock of chum spawning and rearing below Bonneville dam could not be made since nearby Hamilton and Hardy Creek juvenile chum also frequent the study area and as of yet too few total GSI samples from chum sampled in the study area are available to analyze.

PLANS FOR FY 2001

We are planning to continue collecting data to determine the status of fall chinook and chum spawning below Bonneville, The Dalles, John Day and McNary dams. We are planning to collect biological data from the fish spawning below Bonneville, The Dalles, John Day and McNary dams to profile stocks and determine stock origins. We will continue to estimate emergence timing of juvenile fall chinook and chum below Bonneville Dam. We are planning to sample juvenile populations to determine migration time and size at time of migration for juvenile fall chinook and chum rearing below Bonneville Dam. We will continue to determine juvenile stock composition. We will continue to monitor entrapment of juvenile chinook and chum below Bonneville Dam. We are planning to investigate the feasibility of coded-wire tagging juvenile fall chinook rearing below Bonneville Dam to determine juvenile to adult survival rate and ocean distribution.

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APPENDIX A

Carcass Tagging Methodology

Carcass Tagging [1/]

General:

This method of estimating the size of a spawning population depends upon the following:

(1) Some idea as to when the carcasses are first present on the spawning ground.

(2) There are at least 5 tagging and sampling days during the spawning season.

(3) The tagging and sampling days are spread throughout the season.

(4) The lapse time between the first and second sampling days is about equal to the interval between the initial occurrence of spawners and the first sampling day.

(5) All recovered carcasses are either tagged and returned to the stream or are removed from the population.

(6) Numbered tags of the same (dull) color are used throughout the sampling period.

(7) Note: Other than the restriction in (4), the time lapse between sampling days need not be equal.

[1/] This method was developed by G. Paulik of the University of Washington. It is an application of the more general multiple release and recapture techniques presented by G. Seber and G. Jolly in Biometrika; vol 49, 1962, and vol. 50, 1963. Prepared by D. Worlund,, Northwest Fisheries Center.

Model and Notation:

		Initial Occurrences	1st sampling	2nd sampling	Etc.		
Time________________________		t_0------	t_1------	t_2-------	t_3------	t_4------	t_5--------
Number of fish dying during time interval		D_0	D_1	D_2	D_3	D_4	
Proportion of D_o not disappearing during time interval		S_0	S_1	S_2	S_3	S_4	
Number of D_i available			B_0	B_1	B_2	B_3	B_4
Total number of carcasses available			N_1	N_2	N_3	N_4	N_5
Total carcasses recovered			C_1	C_2	C_3	C_4	C_5
Number tags released			T_1	T_2	T_3	T_4	T_5
Number tags recovered from C_i			$R_{1.}$ (=0)	$R_{2.}$	$R_{3.}$	$R_{4.}$	$R_{5.}$
Number tags recovered from T_i			$R_{1.}$ (=0)	$R_{2.}$	$R_{3.}$	$R_{4.}$	$R_{5.}$
Number carcasses tagged <u>before</u> i^{th} sample <u>and</u> recovered <u>after</u> the i^{th} period.	⇒		Z_1	Z_2	Z_3	Z_4	Z_5
Number of tagged carcasses available	⇒		(=0) M_1	M_2	M_3	M_4	M_5
Probability of recovering a carcass	⇒		U_1	U_2	U_3	U_4	U_5
Proportion of population of carcasses that are tagged	⇒		f_1	f_2	f_3	f_4	f_5

Estimating Equations:

An estimate of the total spawning population, E, is the sum of the estimated $\hat{D}_i$.

$$\hat{E} = \hat{D}_o + \hat{D}_1 + \hat{D}_2 + \text{----------} + \hat{D}_{I-1}$$

Where I is the last sampling day.

Two basic quantities to be calculated (work sheet A) are $\hat{M}_i$ and $\hat{f}_i$:

$$\hat{M}_i = \frac{Z_i}{R_{.i}/T_i} + R_{i.}$$

$$= \left[\frac{T_i Z_i}{R_{.i}}\right] + R_{i.} \qquad (i = 2, 3, \text{----}, I-1)$$

$$\text{And } \hat{f}_i = \frac{R_{i.}}{C_i} \qquad (i = 1, 2, \text{----}, I)$$

Having these estimates one can then calculate (worksheet B):

$$\hat{N}_i = \frac{\hat{M}_i}{\hat{f}_I} \qquad (i = 2, 3, ----, I\text{-}1)$$

$$\hat{s}_i \quad \frac{\hat{M}_{i+1}}{\hat{M}_i - R_{i.} + T_i} \qquad (i = 1, 2, ----, I\text{-}2)$$

$$\hat{u}_i = \frac{C_i}{\hat{N}_i} \qquad (i = 2, 3, ----, I\text{-}1)$$

$$\hat{B}_i = \hat{N}_{i+1} - \hat{s}_i(\hat{N}_i - C_i + T_i) \qquad (i = 2, 3, ----, I\text{-}2)$$

Then $$\hat{D}_1 = \frac{\hat{B}_i}{\int \hat{s}_i} \qquad (i = 2, 3, ----, I\text{-}2)$$

There is left to calculate D_o, D_1, and D_{I-1} :

D_1 : Note:- $M_1 = R_{1.} = o$

Then $\hat{s}_1 = \frac{\hat{M}_2}{T_1}$

<u>Assume</u> $u_1 = u_2$

Then $\hat{N}_1 = \dfrac{C_1}{\hat{u}_1} = \dfrac{C_1}{\hat{u}_2}$

$\hat{B}_1 = \hat{N}_2 - \hat{s}_1(\hat{N}_1 - C_1 + T_1)$

and $\hat{D}_1 = \dfrac{\hat{B}_1}{\int \hat{s}_l}$

D_o: note: $- B_o = N_1$

Then $\hat{D}_o = N_1 \quad \dfrac{T_1 - T_o}{2(t2 - t1)} \quad (1n\, \hat{s}_1)$

APPENDIX B

Sampling data of incidentally caught juvenile salmonids

Appendix Table B. Mean fork lengths of juvenile coho, cutthroat, steelhead and sockeye sampled below Bonneville Dam, 2000.

	Coho	Cutthroat	Steelhead	Sockeye
Adipose fin clip				
Number	224	0	0	4
Mean Length	128.0	0.0	0.0	88.8
No Adipose fin clip				
Number	105	4	5	2
Mean Length	125.0	254.0	202.4	73.5